

THE JOURNEY OF BUILDING DEFENCE TECHNOLOGICAL CAPABILITY



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PROGRESS in science and technology is the very foundation of enhancing the comprehensive national power of the country and strengthening national security in every domain. The technological backbone of any armed force of a nation is indigenous defence research and development. In India, the Defence Research and Development Organisation (DRDO) has played a pivotal role in developing defence systems encompassing advanced technologies and providing critical fighting capabilities to the armed forces.

The genesis of DRDO can be linked to the creation of the Directorate of Technical Development (DTD) in 1945 – post World War II. Two years later, India became independent leading to the appointment of the Scientific Advisor to the Prime Minister. Establishment of the Defence Science Organisation (DSO) happened in 1948 and under this first laboratory was created in 1950. In 1958, the Defence Research and Development Organisation (DRDO) was formed by merging DSO and DTD, with Scientific Adviser to Raksha Mantri as its Head. DRDO had 10 laboratories at that time.

Today, DRDO has grown into a leader in the domain of strategic systems and other defence technologies. Starting from the design of simple equipment to the development of the most advanced systems DRDO has continued its quest for indigenous defence systems development. From the first grant of Rs 15 Lakh in 1950 and a yearly budget allocation of Rs 3.17 Crore in 1961-62, DRDO now has a budget allocation of about Rs 20,000 Crore for the fiscal year 2021-22. In spite of the denials and embargos from various control regimes, DRDO has been persistently moving in the direction of defence technology growth.

In the process of developing contemporary and advanced systems for defence, DRDO has acquired a large number of inherent diverse technical capabilities. These include design, development and integration of highly complex systems using cutting-edge technologies. DRDO has across various domains of defence applications – Aeronautics, Combat Vehicles, Naval Systems, Missiles, Armaments, Electronics, Engineering Systems, Instrumentation, Information Systems, Special

Materials, Life Sciences, Advanced Computing, Warfare Simulation and Training.

Missiles, Armament and Ammunition

Starting from the mid-eighties of the previous century, the technology demonstration of ballistic missiles has culminated into India's missile deterrence programme consisting of Prithvi and Agni series of ballistic missiles meeting different ranges and requirements. India is the seventh country in the world to have long-range ballistic missiles.

India is also the fifth country in the world to have developed an indigenous ballistic missile defence programme. Ballistic Missile Defence systems to intercept targets in exo- and endo-atmospheres are designed and developed by DRDO. Mission Shakti, the anti-satellite technology is a milestone towards building the Nation's strength to defend its space assets. India is the fourth nation in the world to have demonstrated this capability based on indigenous technology.

The development of Air-to-Air, Surface-to-Air, Anti-Tank Missiles,



Agni

Smart Bombs, Guided Rockets, Air launched Missiles and Anti-Radiation missiles for different segments of defence operations has not only enhanced our defence capability but given a big boost to our international image and also saved a large share of foreign exchange.

'Astra', the first indigenous beyond visual range air-to-air missile has enabled India to join the select group of nations that possess a weapon of this capability and performance. After integration with Su-30MKI aircraft, it is planned to be integrated on the indigenous Tejas, upgraded Mirage 2000 and MiG-29 fighter aircrafts.

Astra Mk-2 with two-pulse propulsion is being developed to further enhance the kill zone of Astra Mk-1 missile. Astra Mk-2 will achieve a longer kill range, one of the highest amongst all air-to-air beyond visual range missiles available across the world thus far. To further increase the 'kill range' to nearly double of the Mk-2 and ensure the wider 'no escape zone', DRDO has successfully tested and validated the solid fuel ducted ramjet propulsion technology.

BrahMos is the fastest supersonic cruise missile of its kind in the world that can be launched from the ground, aircraft and ship. The latest development is that an air-launched

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variant of BrahMos became operational on Su-30MKI fighters of Indian Air Force.

Akash Surface-to-Air Missile (SAM) is deployed with the Indian Air Force and Indian Army to defend the air space of the country. quick reaction SAM has been developed for mobile air defence applications, which will enter into production shortly. DRDO in partnership with Israeli Aerospace Industries has developed medium range surface to air missile with a longer kill range for the tri-services application.

Akash-NG SAM is being designed and developed for providing air defence cover against fighter aircrafts, helicopters, UAVs, sub-sonic cruise missiles and low radar signatures targets. Long Range Surface-to-Air Missile is being taken up by DRDO to increase the air defence against air threats emanating from longer ranges.

DRDO has also developed the smart anti-airfield weapon, which is a state-of-the-art deep-penetration and high explosive glide bomb designed to target runways of an airfield from stand-off distance with great precision.

New generation anti-radiation missile called Rudram series, air-to-ground, long-range, precision, stand-off supersonic weapons are being developed for varying ranges for launching from the aircrafts of IAF.

Multiple missiles for Navy are being developed. These include



Astra



ASAT Interceptor

helicopter-launched short range naval anti-ship missile and aircraft launched medium range anti ship missile. Only USA, Russia and China have the capability to launch anti-ship missiles.

The long range anti-ship missile is a land launched medium-range anti-ship missile, which will be able to target naval surface targets. Extended range anti-submarine rocket is a ship-launched rocket being developed by DRDO for anti-submarine warfare. Long Range long range land attack cruise missile is being developed with launching capability from ship and land platforms against land targets.

Third generation fire and forget anti-tank missile Nag and Helina helicopter launched anti-tank missile are equipped with an infra red imaging seeker with 'Lock-on Before Launch' capability. Man-Portable Anti-Tank Guided Missile (MPATGM) is in advanced stage of development. In addition, the laser guided anti tank missile for MBT is in final stages of development.

Stand-off Anti-Tank (SANT) Missile is a helicopter launched anti-tank missile equipped with an active radar seeker with 'Lock-on Before Launch' capability.

India has been building many systems for the Indian Army. The Main Battle Tank (MBT) Arjun has been

“India is the 7th country in the world to have long-range ballistic missiles; 5th in the world to have developed an indigenous ballistic missile defence programme and 4th nation in the world to have demonstrated anti-satellite technology.”

developed by DRDO for the Army keeping in view Indian conditions. The tank has been in service with the Indian Army since 2004 and Arjun MK-1(A) is being inducted with many improvements over Arjun MK-1. The New Generation Main Battle Tank (NG-MBT) is envisaged as the futuristic MBT of the Indian Army. It will be a medium tank powered by 1500 HP engine and armed with a 125 mm smoothbore gun. Allelectric turret drive, explosive reactive armour and active protection system are being developed for the new generation of tanks.

DRDO has delivered multiple bridging systems to the Indian Army which are deployed at strategic locations. Recently, Mountain Foot Over Bridge has been developed and will be shortly delivered for active use in the field by production agency.

Pinaka free flight rocket system has been the workhorse artillery weapon for the Indian Army for many years. Pinaka rockets are launched from a multi-barrel rocket launcher



Akash-NG



Brahmos

which has the capability to launch a salvo of rockets. DRDO has developed the extended range Pinaka-ER with improved propulsion and new warhead configurations.

ATAGS 155 mm gun has been developed with the longest firing range in the world. 155 mm shells also have been developed for ATAGS indigenously so that there will not be any deficiency. The gun can fire existing ammunition being used by erstwhile Bofors and other guns.

An advanced version of the hand grenade, Multi-Mode Hand Grenade, with several security features has been developed and is being produced in large numbers by Ordnance Factory and private industry. DRDO has also designed 5.56x30 mm Joint Venture Protective Carbine (JVPC) which has features like high reliability, low recoil, retractable butt, ergonomic design, single hand firing capability, and multiple Picatinny rails.

Unmanned Aerial Vehicles (UAVs)

DRDO developed UAV Lakshya has been proven and is being successfully utilised by the Services. It is a cost-effective re-usable subsonic aerial target system powered by a gas turbine engine and launched either from land or ship.

Nishant is a multi-mission UAV with day/night capability used for battlefield surveillance and reconnaissance, target



Abhyas

tracking & localisation, and artillery fire correction. A sophisticated image processing system is used for analysing the images transmitted from the UAV.

Rustom-I is an all composite, 800 kg class remotely piloted aircraft system having capabilities of Intelligence, Surveillance, Reconnaissance, Target Acquisition/Tracking and Image Exploitation. Rustom-I is the first Indian remotely piloted system to have conventional take-off and landing capability. It has autonomous flight mode and Get-to-Home features.

Rustom-II is a platform being developed for long duration surveillance and reconnaissance, target identification, target tracking and battlefield damage assessment. It can carry a variety of various electro-optical and intelligence payloads. This will provide continuous wide area coverage and yet be able to identify small targets. Another multi-mission UAV is being developed to carry out Intelligence, Surveillance, and Reconnaissance (ISR) roles.

Abhyas being developed is expendable, low cost, high speed unmanned aerial target fitted with sensors and is GPS enabled. It will have onboard actuators, a flight control computer and a miss distance indicator. In addition, supersonic aerial target is also under development.

Fighter Aircrafts

Developing fighter aircrafts is an extremely complex process involving cutting-edge technologies in numerous fields. First Technology Demonstrator of Tejas, flew its maiden flight on 4 January 2001. Since then, Tejas prototypes and limited series production aircraft flew over 4,400 development flight test sorties culminating in



LCA- Tejas

its initial operational clearance in December 2013 and final operational clearance in February 2019. Tejas development timelines achieved by India are comparable with those of many other contemporary aircraft designed elsewhere in the world.

Tejas Mk-1 is an all-weather multi-role fighter capable of carrying close combat and beyond visual range air-to-air missiles coupled with multi-mode air-interception radar for the air defence role. It is capable of delivering all types of conventional bombs and Laser Guided Bombs in the ground attack role. Tejas Mk-1 is the smallest and lightest in its class of contemporary supersonic combat fighter aircrafts. The aircraft is equipped with advanced avionics systems and sensors for an excellent flying experience.

Technologies for deck-based landing and take-off have been successfully developed and demonstrated as part of the LCA-Navy programme. Two prototypes of the Naval version of the LCA, Navy Trainer and Navy Fighter, successfully undertook maiden arrested landing and ski-jump take-off onboard INS Vikramaditya in January 2020. Both the aircrafts conducted a total of 18 ski-jump take-offs and 18 arrested landing onboard INS Vikramaditya in five days. DRDO has nurtured and hand held the Indian industry

to reach the level of manufacturing to meet the stringent quality assurance requirements specified for aviation equipment. This is a major contribution towards self-reliance in the manufacturing of the product and its life-cycle support. LCA project has made India 'AtmaNirbhar' in most contemporary technologies related to fighter aircrafts.

DRDO has started the design and development of the next-gen fighter aircraft LCA Tejas Mk-2, the 4.5+ generation multi-role fighter aircraft. Tejas Mk-2 will incorporate more weapon stations capable of carrying higher weapon load compared to Mk-1 and retractable air-to-air refuelling probe.

Advanced Medium Combat Aircraft (AMCA) is India's Fifth Generation Stealth Fighter Aircraft (FGFA) and is being developed indigenously by DRDO. Only USA, Russia and China have so far developed FGFA. AMCA will include every advanced stealth technology. The aircraft will be equipped with state-of-the-art indigenous radar, inbuilt feature for passive detection of aircraft and internally mounted electronic warfare suite. AMCA will be a twin-engine fighter primarily designed for stealth to enable it to penetrate deep inside enemy territory and attack heavily defended targets with the help of net

“DRDO has started the design and development of the next-gen fighter aircraft design of LCA Tejas Mk-2, the 4.5+ generation multi-role fighter aircraft.”

centric warfare operations and data fusion based enhanced situational awareness for the pilot.

Radars and Surveillance Systems

The contribution of DRDO in improving the air defence ground environmental system of the Nation is immense. Many radars have been designed and developed by DRDO, which are network ready.

Weapon locating radar called Swathi to identify the location of hostile artillery, mortars and rocket launchers, based on the projectile trajectory has been developed exclusively for army applications. This radar has got export orders also. Battle field surveillance radar has been developed for frontline units of the Indian Army and hundreds of these radars are already being used in the field. Low level tracking radar for applications in mountains has been developed and is being used by the Indian Army.

Through wall imaging radar, a sensor used for detection and location of static and moving targets, especially human beings behind walls, is under development. foliage penetration radar is under development for detection of personnel and vehicles hiding behind camouflaged tree and forest cover for low-intensity conflict. Many of the DRDO developed radars are integrated to provide a composite air situation picture to display and control every airborne platform over the entire Indian airspace including the island territories.

The lower range 'Aslesha' low level light weight radar can be carried by two people. It can also be carried under slung below a helicopter. These radars are deployed to plug gaps in the air defence surveillance especially in mountainous and remote areas.



AEW&C (Netra)

‘Arudhra’ medium powered and ‘Ashwini’ low level tracking radars are in final stages of testing and will be used for providing air defence surveillance in three dimensions at different ranges. These will be configured specifically for use in mountain regions to ensure maximum coverage.

Active electronically scanned array based indigenously developed ‘Uttam’ radar for fighter aircraft has been flight tested on the LCA aircraft. The performance of the radar is very promising. Uttam radar will be equipped in Tejas and AMCA fighters.

Two indigenously developed ‘Netra’ Airborne Early Warning & Control (AEW&C) aircrafts are operating with IAF. ‘Netra’ AEW&C aircraft are equipped with indigenously developed mission systems for air situation picture of the battlefield.

DRDO developed ground based mobile electronic systems having electronic surveillance measures and communication surveillance measures have been deployed.

Tripod mounted compact Anti-Drone system integrated with jammer, electro-optical tracking system, and radar was successfully demonstrated during August 2020. Detection, jamming, and destruction of Drones were successfully demonstrated. The system was deployed for security during Republic Day celebrations 2021.

The laser dazzler developed by DRDO is used as a non-lethal method for warning and stopping suspicious vehicles/boats/aircraft/UAVs from approaching secured areas during both day and night. It is capable of dazzle and thereby suppresses the person’s/

optical sensor’s actions with disability glare in case of non-compliance to orders. It also dazzles and distracts aircraft/UAVs.

Electronic Warfare Systems

Electronic Warfare (EW) plays a crucial role in modern day air combat. Several elements of EW self-protection suite developed by DRDO are installed on IAF fighter and transport aircraft and helicopters. These are radar warning receivers, countermeasures dispensing system, missile approach warning system, jammers etc. DRDO has developed software defined radios in 5 form-factors to provide wireless secure communication capability to both mobile and fixed forces as required by the Indian Navy.

Naval Systems and Applications

DRDO has worked on the development of materials for the construction of naval platforms. High strength steels for the construction of submarine hulls have been developed. Henceforth, all Indian submarines will be made with Indian steel. Besides, for shipbuilding DRDO has developed steel plates that are about one fourth to one eighth the cost of imported plates.

Some other technologies developed by DRDO include titanium sponge produced indigenously from the sands of Kerala; rubber tiles to reduce transmitted noise for submarines; epoxy putty for fixing the tiles; air independent propulsion system that enhances the submerged endurance of the submarine.

DRDO is in advanced stage of development of submarine periscope. Submarine hoistable masts for



Anti-Drone System

periscope, radar and communication antennae are also being developed. DRDO is developing a universal vertical launcher capable of launching all the indigenous missiles onboard Indian Naval Ships.

Sonars developed by DRDO are in use in various ships and submarines of the Indian Navy. The Sonar suites are being productionised by M/s BEL. Sonar domes and sonobuoys developed by DRDO are also being used by the Indian Navy.

Underwater Weapons and Countermeasure Systems

DRDO has developed multi-purpose torpedoes along with Torpedo fire control systems for the Indian Navy. Advanced light weight torpedo is an anti-submarine, electrically propelled, self-homing torpedo which can be launched from ship and rotary-wing aircraft. Varunastra is ship launched, heavy weight, electrically-propelled, anti-submarine torpedo capable of targeting quiet submarines, both in deep and shallow waters in an intense countermeasure environment.

Electrical heavy weight torpedo, a new generation torpedo that can be launched from both ships and submarines for anti-submarine warfare, is under development. Jalastra, a

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medium weight torpedo capable of being launched from naval platforms, is also under development.

For launching light weight torpedoes from onboard Indian ships with anti-submarine warfare role, DRDO has developed triple tube launchers, which are being productionised by the private industry and are deployed on many Indian Navy Ships.

Mareech advanced torpedo defence system is a torpedo detection and countermeasure system capable of detecting, confusing, diverting and decoying incoming torpedoes. DRDO has also demonstrated missile assisted release of light weight anti-submarine torpedo system for underwater warfare operations far beyond torpedo range.

Other Systems

Advanced support systems have been developed by DRDO to enhance survivability, sustainability, mobility, performance and habitability of soldiers in extreme & toxic environments, high altitudes, deserts, underwater, aerospace, closed micro-environments of ships, aircrafts and areas of low intensity conflicts. Some examples are life support systems (i.e., Oxygen Support System, Protective clothing & equipment) and communication Systems.

Heavy drop parachutes, Combat Free Fall systems and a number of other personnel parachutes are being used by the Parachute Regiment and Special Forces for combat/special missions at about 30,000 ft. Pilot parachutes for Mig-21, Mig-27, MiG-29, Su-30 MKI, Jaguar and Mirage-2000 have also been indigenised.

State-of-the-art food technologies including post-harvest technology; ready-to-eat food products; packaging systems and processing technologies for fresh and processed food for Armed Forces have been developed. Glacier caps, face masks, jackets, glacier gaiters, gloves, ponchos for protection of head from cold in Glacier region are being used by Indian Army.

Technologies have been developed related to protection against explosives

and fire. Advanced oxidation process technology is developed for the treatment of toxic and hazardous effluents. Stabilisation/solidification technology is developed for the disposal of toxic heavy metals and other concentrated toxic/hazardous organic wastes. DRDO has also developed precipitative, adsorptive and electro-chemical techniques for the treatment of heavy metals and polyurea based polymeric coatings for blast mitigation.

DRDO is also equipped with many advanced test facilities for the development of defence technologies. Hypersonic wind tunnel test facility, shore-based test facility, manoeuvring basin, EMI/EMC setups, shock and vibration setups for various parameters, aeronautical test range and many other facilities are also being used by Indian industry for making the defence systems.

Glorious History & Bright Future

During the journey of 63 years after its inception, DRDO has been continuously developing defence systems for the Nation, often in collaboration with various R&D laboratories.

While a brief glimpse of some of the systems has been provided here, there are many other systems that have been developed and deployed in the service of the nation.

DRDO is working on upcoming technologies like Quantum, Hypersonics, advanced materials for defence applications, network enabled defence systems and AI for defence. and Artificial Intelligence for Defence. Hypersonic Technology Demonstrator Vehicle (HSDTV) has been successfully tested last year, making India the fourth country in the world to have demonstrated this technology. DRDO



Hypersonic Wind Tunnel

“While close hand-holding of DRDO with Indian industry partners has helped spawn a robust defence industry in the country, DRDO is also promoting innovation in startups and students through its various schemes.”



Hypersonic Technology Demonstrator Vehicle

laboratories are working on a well laid out plan for the next generation of missiles, aircrafts, tanks, sensors, underwater systems and armaments.

While close hand-holding of DRDO with Indian industry partners has helped spawn a robust defence industry in the country, DRDO is promoting innovation in startups and students through its various schemes. DRDO of the 21st century is taking up challenging assignments with an eye on the future defence preparedness of the country.

